Bulletin 578

Guidelines for Expert Soybean Harvesting

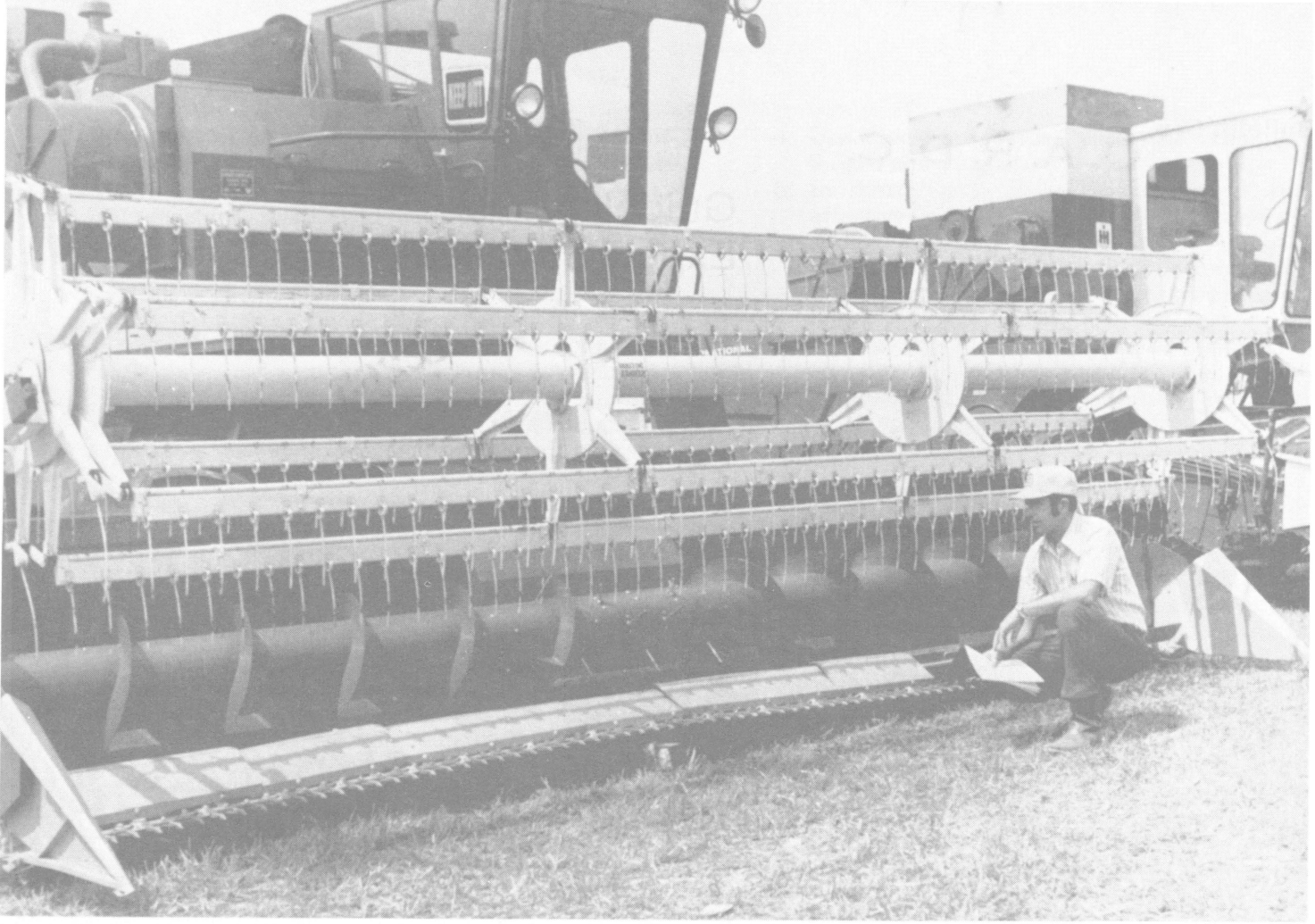

Figure 1. The combine operator must know his equipment and how to adjust it for different crop conditions if he is to minimize harvest losses. This combine is equipped with a flexible floating cutterbar extension.

Guidelines for Expert Soybean Harvesting

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The opportunity for a soybean producer to do an "expert" job of harvesting soybeans is greater today than at any previous time in history! This has come about, I believe, because of a number of happenings that have tended to build—one upon the other—to the point that if a farmer "commits" himself to doing an expert job of harvesting soybeans, he can do it!

REASONS BEHIND PROGRESS

Events over the past 8 years that have made expert soybean harvesting a reality today include:

1. University research and extension engineers have done an excellent job determining harvest loss levels, their source, what could be done to reduce them, and what loss levels should be acceptable for harvesting soybeans.
2. The farm machinery industry, original manufacturers as well as short line companies, have been providing new machine

accessories and new machine designs that are improving harvesting efficiency—and more improvements are on the way.

3. The increasing demand for protein in the world market and the ability to increase soybean production to meet that demand has changed the image for soybeans. So, farmers are listening.
4. The world economy, that has generated the highest soybean prices levels ever known, has caused farmers to become efficiency minded. They can calculate what loss levels of 3 and 4 bu/acre mean to their profit margin, and they don't like it.
5. The various soybean associations and other organizations interested in soybeans have done an excellent job of spreading the word on what needs to be done and how to do it.
6. The newly arrived "Energy Crisis" will cause soybean producers to improve their production efficiency still further. They will want to harvest every bean they grow—and well they should.

So, with this brief history of events, I will seek to explain how "expert soybean harvesting" can come about and why producers should commit themselves to doing a better job.

What is an Expert?

What I mean by an expert job of harvesting soybeans is a field loss of 3% or less. If it is 5% of yield, you are good. But, if it's 10% to 12% of yield, you're just average. And, keep in mind that the average is improving slightly each year—so average operators will have to do better just to continue to be average.

Extra Bushels Mean More Dollars

Every extra bushel saved at harvest is clear profit. In fact, with current soybean prices, the dollar value "per hour" for expert harvesting over average harvesting is quite impressive. With soybeans at $6/bu and combining 3 acres/hour, the increased return for an expert job of harvesting is $50.40 (table 1). With an opportunity to gain $50/hour, how can you not make the commitment to become an expert combine operator?

KEYS TO EFFICIENT HARVESTING

Doing an expert job of harvesting isn't easy. There are certain things you will have to recognize and measure to help evaluate the situation and make the right decision.

Table 1. Value of improved harvesting efficiency

Total yield	Harvesting loss		Value	Acres per	Lost	Gained
bu/acre	%	Bu/acre	$/bu	hour	$/hour	$/hour
40	10 (ave.)	4.0	6.00	3.0	72.00	–
40	5 (good)	2.0	6.00	3.0	36.00	36.00
40	3 (expert)	1.2	6.00	3.0	21.60	50.40

In checking harvesting losses in Ohio, whether soybeans or corn, we soon realized that certain key steps should be followed to reduce losses. These key steps are:

1. Know where losses commonly occur and why.
2. Know how to quickly measure these losses.
3. Know what losses are considered reasonable from the various machine components.
4. Know what machine accessories and cultural practices will help reduce losses.
5. Know what machine adjustments and operating practices will keep losses to a minimum.

Types of Losses

1. Preharvest loss consists of loose beans and beans in pods detached from the stalks and lying on the ground prior to harvesting. These should not be charged against the machine.
2. Gathering unit loss is the sum of the following specific losses:
   a. Shatter loss—beans free of pods and pods free of the stalk, resulting from harvesting (figure 2).
   b. Stubble loss—beans remaining in pods attached to the stubble (figure 3).
   c. Lodged loss—beans remaining in pods attached to stalks which were not cut (figure 4).
   d. Stalk loss—beans remaining in pods attached to stalks which were cut but not delivered to the harvester (figure 5).
3. Cylinder loss is unthreshed beans remaining in pods which are passed through the harvester.
4. Separation loss consists of beans free of pods which were discharged from the combine separator.

The most difficult problem in harvesting soybeans is to get all beans into the machine. Bean pods may set low on the stalk, close to the ground. Beans also tend to shatter and fall to the ground. The net result is that beans lost at the gathering unit account for more than 90% of the total loss. Also, more than 50% of this gathering loss is

Figure 2. Shatter loss—loose beans and beans in loose pods on the ground are usually the greatest losses occurring in the gathering operation.

Figure 3. Stubble loss—beans in pods on stubble below knife cut can be excessive unless the knife skims over the ground.

Figure 4. Lodged stalk loss—note all the pods on the stalk still attached to the ground.

Figure 5. Loose stalk loss is portions of stalk that slide from the header and are often re-cut into lengths of 6 to 8 inches or stalks that ride over on the reel and are re-cut.

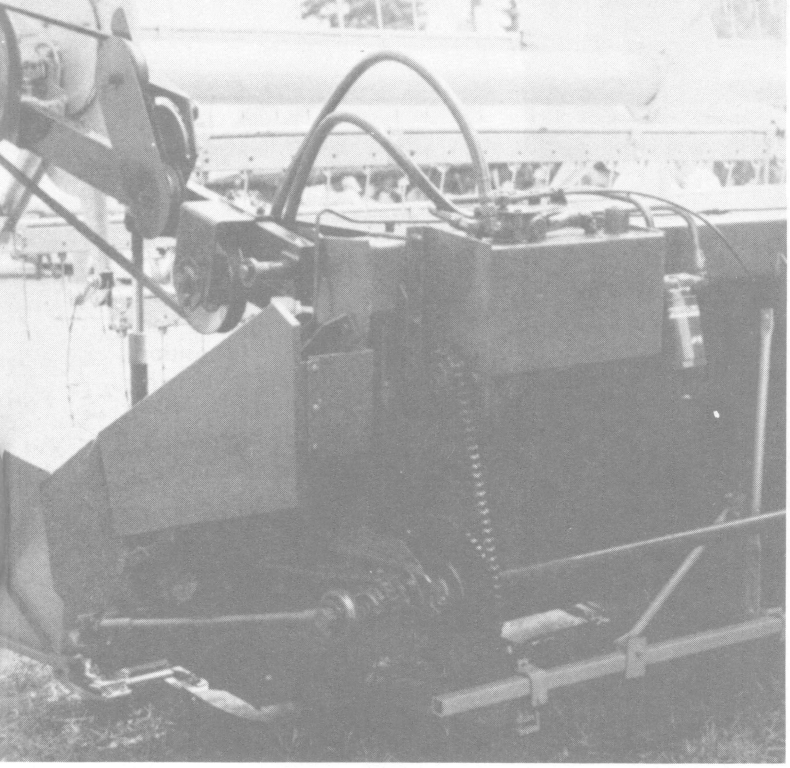


Figure 6. The hydraulic motor makes it possible to change reel speed "on the go" to best suit the conditions of the crop.

shatter loss. Our challenge then is to operate the combine so gently and accurately that all the beans enter the machine. Thus, much attention must be directed to the combine header and its operation.

Operation of Reel

Excessive reel speed in relationship to ground speed is one of the most common causes for excessive shattering. Most older machines have a fixed drive assembly for the reel. Consequently, once you select a specific drive sheave or sprocket, the reel speed is set for a related ground speed. If you drive at a slower ground speed, the reel has a flailing action that results in excessive shattering.

The reel should have a speed of rotation that lays the beans gently back on the cutterbar as the knife cuts the stalks. You can see this best by walking beside the machine and noting the action of the reel. The desired action will occur when the peripheral speed of the reel is 25% to 50% faster than ground speed, depending upon the type of bean being harvested. The faster reel speed is needed for the bushy, spreading type of bean plant, whereas the slower speed is desirable for the single stem type of plant.

A "variable reel speed drive" (figure 6) is available on all new combines; it also can be added to many older combines. This makes it possible to select the optimum reel speed to match the crop condition. In my experience, this unit should be standard on every grain combine.

Proper reel positioning also influences shatter loss as well as lodged loss and stalk loss. Positioning the reel too far forward permits excessive flailing of the bean stalk. Running the reel too deep into the beans causes stalks to ride over on the reel in addition to excessive shattering. Running the reel too high causes lodged stalks to be missed.

Reel position is fixed on many older machines. Thus, there may be many places in any field where the reel height is incorrect. There is little you can do about it unless you add a "reel position control." This control consists of two hydraulic cylinders that make it possible to raise the reel "up and down" above the cutterbar while the machine is in motion. It has been classified as an accessory on most machines, but is becoming standard on many machines. This reel position control is essential for doing a peak job of harvesting (figure 7).

Figure 7. Hydraulic cylinders permit easy "height control" on the reel to provide ideal control of the crop.

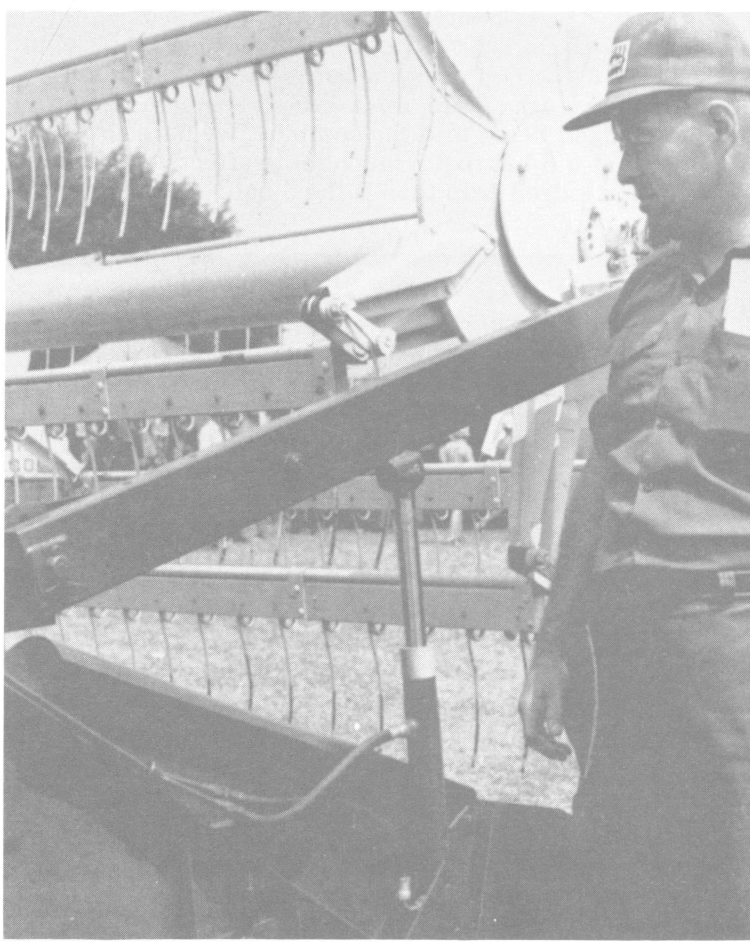


Figure 8. The flexible, floating cutterbar mounts ahead of and below the original knife position and can leave a stubble length of 1 to 1.5 inches.

The "pick up type reel" is desirable over the "bat type reel." If soybeans never lodged, a bat type reel might be satisfactory; but, where lodging occurs, a pick up type reel, used in conjunction with the reel position control and the variable reel speed drive, can do a remarkable job of moving lodged beans into the combine. We have also found that a 6-bat reel is much more effective in handling the lodged crop than is the 5-bat reel.

Figure 9. A stubble cut, 1 to 1.5 inches above the ground is possible with the floating cutterbar extension.

Positioning Cutterbar

Operating the cutterbar too high above the ground is another common cause for excessive bean loss. Bean pods, cut by the knife sections, will shatter and many of the beans will fall to the ground. Also, all pods below the knife will be left on the stubble.

The cutterbar should be operated right on the ground in order to get all the beans. However, doing this on a modern self-propelled combine is most difficult and frustrating. The operator, sitting above and behind the cutterbar, must have excellent depth perception and reflexes to constantly keep the cutterbar at its proper height.

This creates the need for another control—the automatic header control or floating header, or better yet, a floating cutterbar extension used in conjunction with the automatic header height sensing unit. The floating cutterbar extension is as its name implies free floating from the rest of the combine and it extends 8 to 10 inches ahead of the usual knife position on the combine (figure 8). The floating feature allows the knife to cut the bean stalk at 1 to 1.5 inches above the ground. This is 2½ inches closer to the ground than usual with the regular header using automatic sensing controls. Also, the knife is free to flex or bend—to follow the contour of the ground—and the knife can stay "flat" on the ground regardless of the rocking action of the combine. Cutting close to the ground greatly reduces stubble loss as well as shatter loss (Figure 9 and 10).

The "extension" of the floating cutting bar is also desirable in that it provides more room

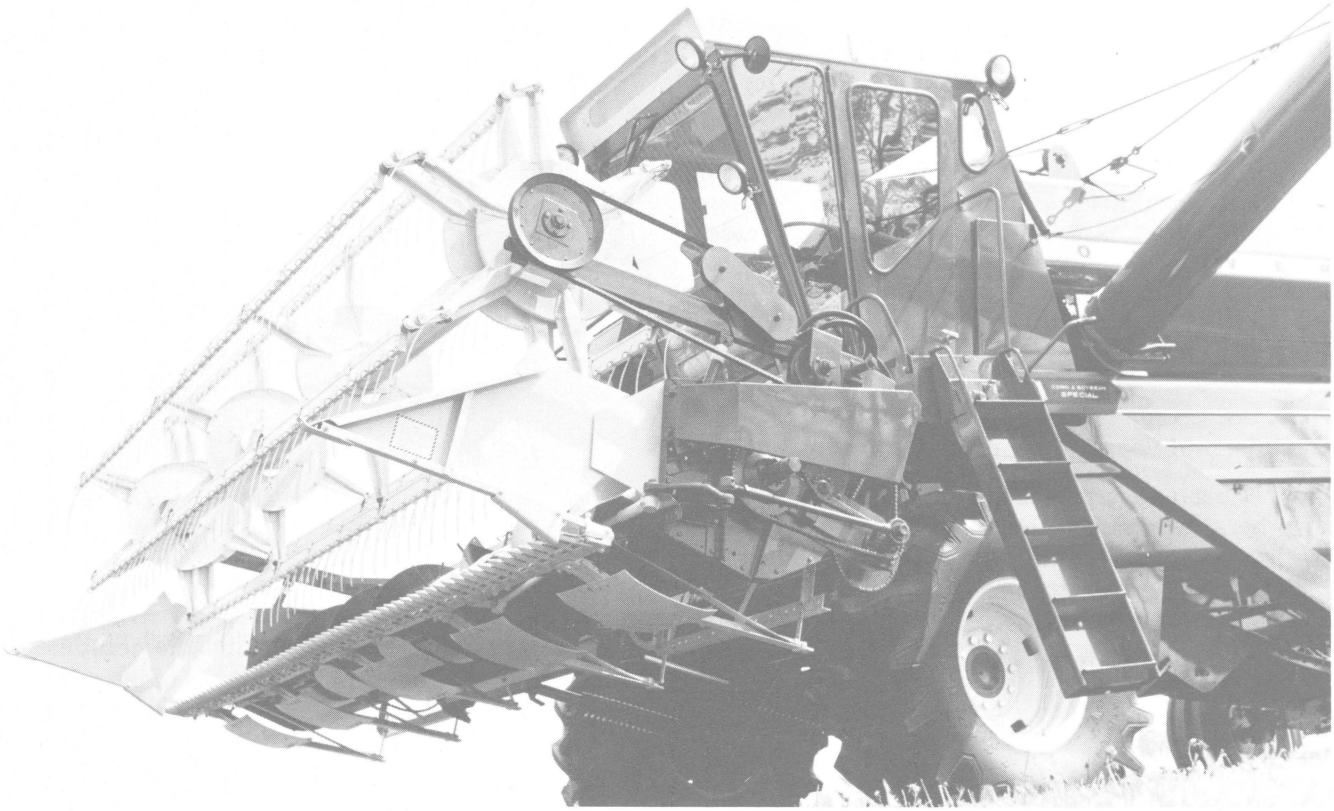


Figure 10. The skid plates, riding over each row, keep the floating cutterbar skimming over the ground independent of the rocking action of the combine. The automatic header control sensing unit can also be used with this cutterbar.

(distance) between the knife and the cross auger of the header. The extra distance allows tall soybean stalks to lay more horizontal before they start moving with the auger. This greatly reduces the recutting loss as well as shatter loss. In our field studies, the floating cutterbar extension can reduce average header losses by 1 to 2 bu/acre. Figure 11 shows the relative merit of the different headers commonly used.

Fear of stones entering and damaging the combine cylinder has influenced farmers to run the cutterbar higher than necessary. A stone trap ahead of the cylinder is an essential item. But why not a stone sensing and ejecting device that will do as its name implies—sense and eject stones—while the machine is in operation? Such a device is needed when harvesting corn as well as soybeans. Our farmers need it and want it; the challenge is for industry to produce it.

The floating cutterbar extension does an effective job of keeping stones out of the combine cylinder. Stones the size of a baseball or softball may ride on top of the knife, but they don't go up the incline into the cross auger. So, the combine operator can stop and pick up the stone or ignore it; in the latter case, the stone will usually vibrate off the knife and the header will pass over it.

I am happy to report that this year at least three major machinery companies provide this floating cutterbar extension as original equipment on their combines. This is certainly a move in the right direction, in my opinion.

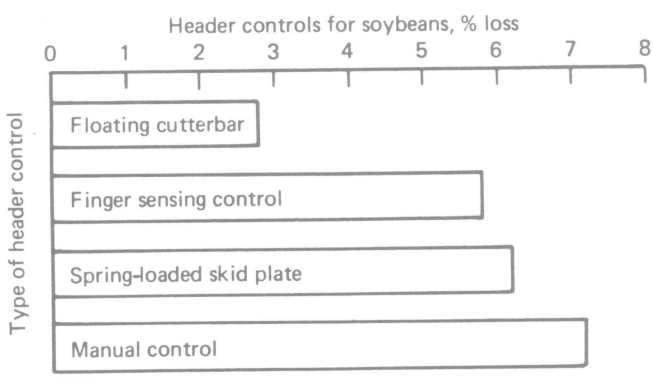


Figure 11. Harvest losses with various combine headers for soybeans (W. R. Nave, University of Illinois).

Aviod Excessive Ground Speed

Excessive forward speed can also cause excessive shatter and stubble loss. Most combines have a fixed knife speed. As forward speed increases beyond 3.2 mph the knife begins stripping the stalk excessively before it is cut. The bean pods, stripped from the stalk, will then shatter, be cut by the knife, and fall to the ground. Uneven height of stubble is an indication of too fast a forward speed for knife speed. Also, as forward speed increases, height of cut usually increases, resulting in more lost beans at the gathering unit. Our work indicates the ideal ground speed is 2.8 to 3.0 mph in clean, standing beans.

Cylinder and Separation Losses

Cylinder and separation losses are usually low; together they should be only 0.1 bu/acre where fields are free of weeds. However, overloading the rack and shoe, due to excessive forward speed or heavy weed growth can cause these losses to increase to nearly 5% of yield.

In his soybean harvest work at the University of Illinois, Ralph Nave reported that cylinder and separation loss in pigweed-infested plots harvested prior to frost was 4.4% at 3 mph as compared to 0.7% at 1 mph. After frost, and after the weeds were disiccated before harvest began, the cylinder and separation loss was the same—about 1%—at both speeds. This indicates that green weeds in mature soybeans are a severe harvest problem unless you are willing to reduce your ground speed by 66%. His work also showed that one smooth pigweed per foot of 30-inch-row beans reduced yield 25% to 30% while the same degree of giant foxtail infestation reduced yield by 13%. This suggests that better weed control measures should receive a higher priority by many soybean producers.

Cylinder and separation losses are usually nil and not easy to measure because of the straw chopper used on so many combines today. The best way to check for cylinder loss is to stop the combine in the field and disengage the threshing mechanisms. Open the door over the straw rack and examine the soybean straw on the rack. You should not find any beans left in pods if threshing is adequate.

Over-threshing frequently is a problem in dry soybeans. Use just enough cylinder speed with the specified cylinder concave clearance to shell the beans from the pods without excessive cracking (Figure 12).

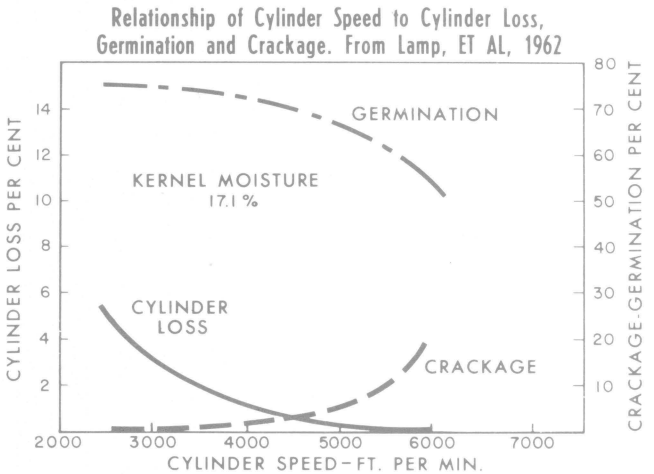


Figure 12. Cylinder speed should be just sufficient to thrash beans from the pods. Excessive cylinder speed causes excessive crackage and reduction in bean germination. The variable speed cylinder control on newer combines makes it easy to adjust cylinder speed.

Separation loss is observed by watching the discharge from the chaffer while the combine is in operation. Beans should not be blowing out or riding out with the chaff. Best recommendation here is to use the "book setting" for sieves and wind, prevent overloading, and then make only small changes in the book settings and measure results.

Figure 13. Pickup guard attachments on each side of the row would be a big help in saving beans that are lodged like this.

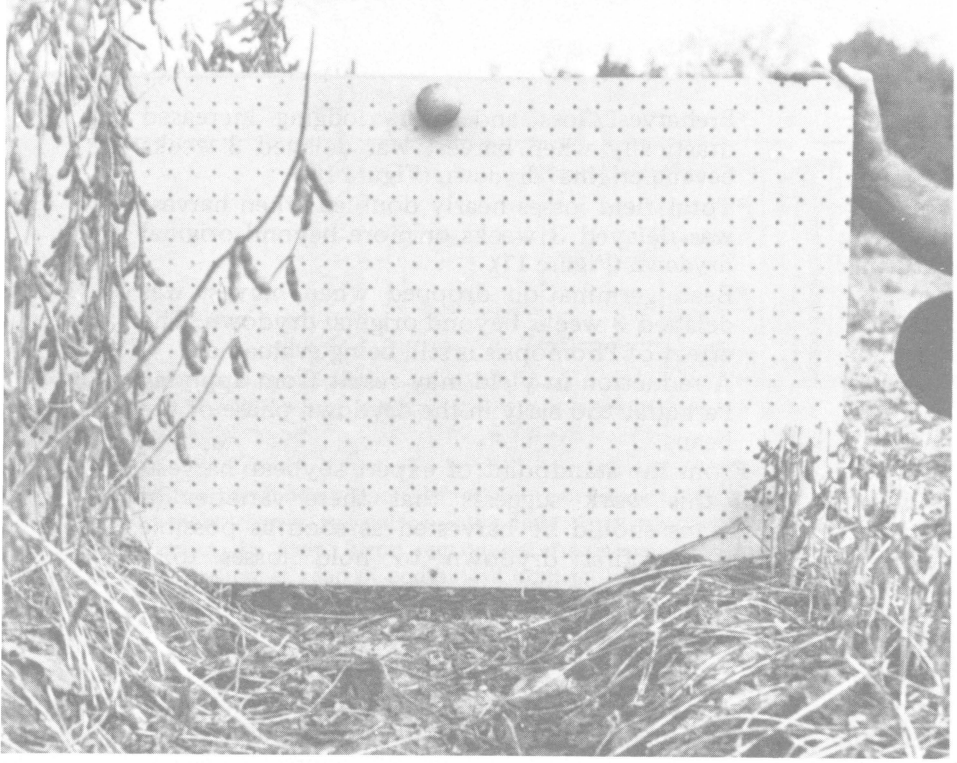
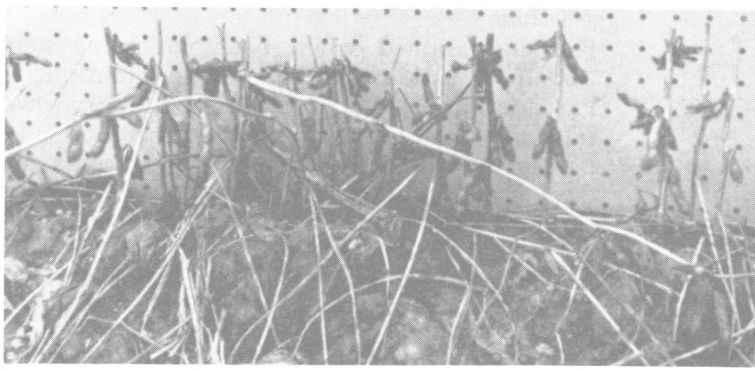


Figure 14. Ridging when cultivating causes losses to "skyrocket" when combine wheel runs up on ridge and combine header is rigid.

Figure 15. Ridging also makes it impossible to cut below the pod set. The stubble loss in this one row is at the rate of 9 bushels per acre.



CULTURAL PRACTICES THAT HELP

Practices that lead to expert soybean harvesting begin long before the combine enters the field. Most important are:

Variety selection——Plant a variety that is well adapted to your region—one that will "stand up" well and hold beans in pods without shattering after drydown (Figure 13).

Level seedbed preparation is essential if combine headers are to skim the ground at harvest. Evidence of dead-furrows and back-furrows must be eliminated.

Cultivation to control weeds should not "earth up" soil around the beans. Earthing-up should be avoided like the plague to retain pod set well above ground level (figures 14 and 15). A rolling cultivator, adjusted to keep the ground level, does an excellent job when timely used. Sweep cultivators with half sweeps near the row are also effective; shovel cultivation should be avoided when the soil is too wet since it can deposit large clods of soil in the soybean row. Then, at harvest, the combine either floats over these clods or cuts through them; either way, the results are not good. Also, any lodged stalks lying below the hilled-up rows will be a sure loss at harvest.

Paraquat as a harvest aid in weedy beans and for seed beans has been studied by agricultural engineers at Ohio State University for the past three seasons. This chemical was approved recently for use on soybeans to stop all plant growth and cause quick drying. Thus, its suitability is for use on soybeans that are mature, but where the fields are heavily infested with green weeds.

Paraquat was applied by air at the rate of 1 pint/acre in 5 gallons of water with X-77 wetting agent when the Wayne beans had dropped 50% of their leaves. It desiccated the weeds so that threshing losses were reduced by 0.6 bu/acre and the bean moisture after harvest was two percentage points less than the control. The net result was an increase in return not quite equal to the cost of the treatment with beans at $3/bu. However, the savings in harvest time and reduced machine breakage and plugging were significant.

Some typical problems encountered while harvesting the untreated weedy beans included: sheared drive pin on the reel; bent divider boards; bent reel bats; broken knife section and guard;

plugged raddle; and plugged clean grain auger. Placing a dollar value on these delays and repairs would make the economics of Paraquat treatment of weedy fields much more favorable. We also believe that the actual harvest savings would have been more pronounced for an earlier maturing variety of soybeans.

In the fall of 1972, Paraquat was applied to a field of Chippewa 64 soybeans to speed their drydown so harvesting could be done at the Ohio Farm Science Review on September 19, 20, and 21. This is an early harvest date for soybeans in Ohio. The Paraquat was again applied aerially when bean moistures varied between 26% and 34%. The moisture drop in the beans varied from 3% to 6% per day, which is nearly double the rate of normal drydown for our area. This permitted harvest on schedule and stimulated interest in more work with Paraquat as an aid to earlier harvest of soybeans.

Our work with Paraquat during the 1973 season involved treatment of two soybean varieties, Chippewa 64 and Beeson, to note the effect of Paraquat and early harvesting on seed quality. The data is still being analyzed, but early observations suggest that:

*Paraquat applied when bean moistures were 35% to 37% did not affect seed germination.

*Paraquat appeared to increase the drydown rate of the Chippewa 64 beans by 50% (6 points per day as compared to 4 points per day) which could permit harvesting 2 to 3 days earlier. It also brought the field of beans into a more uniform level of dryness.

*The Paraquat treatment did not appear to have any effect on plant lodging or preharvest losses.

*Preharvest loss and plant lodging increased drastically when harvest was delayed 3 weeks beyond original drydown (Figure 16).

*Total field losses nearly doubled when harvest was delayed 3 weeks or more beyond original drydown (Figure 17).

*Bean germination dropped when harvest was delayed 3 weeks beyond original drydown. The effect of Phomopsis is still being evaluated.

*A reduction in yield may result from applying Paraquat too early in the drydown phase of the beans.

From the standpoint of expert soybean harvesting, this work suggests that these varieties of soybeans should be harvested as soon as possible after the first drydown to hold losses to a minimum.

PINPOINT AND MEASURE LOSSES

A sure way to increase harvested yields is to use a fast, easy method for measuring machine losses.

Unless you know how much you are losing and from what part of the machine this loss is coming, it is impossible to know for sure what corrections to make in machine adjustment. Also, how do you know if these adjustments actually improved the situation? Or made it worse? Measurement is essential!

The method of loss measurement that I have found most practical for farmer use is based upon the number of beans lost per unit area. If you are losing four beans per square ft of area, you're losing about 1 bu/acre. An easy way to estimate

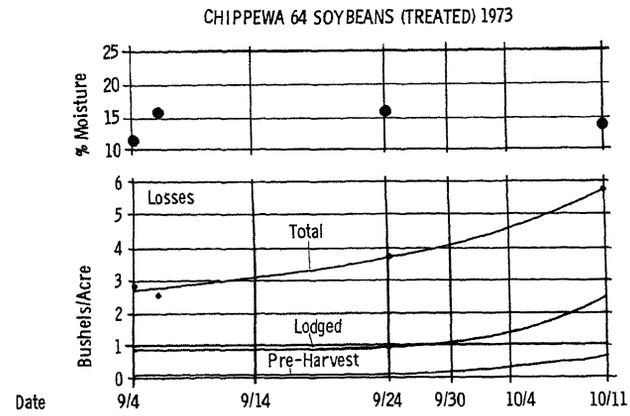


Figure 16. Harvest loss was lowest when these Chippewa 64 soybeans were harvested when their moisture first approached 13%. Preharvest loss, lodged loss and total loss increased rapidly with a 3 week delay.

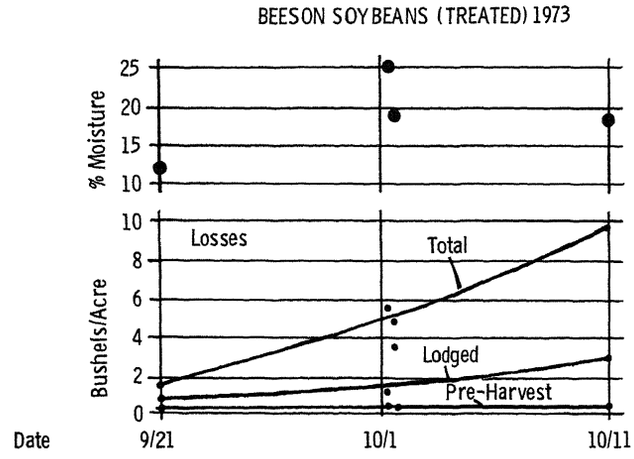
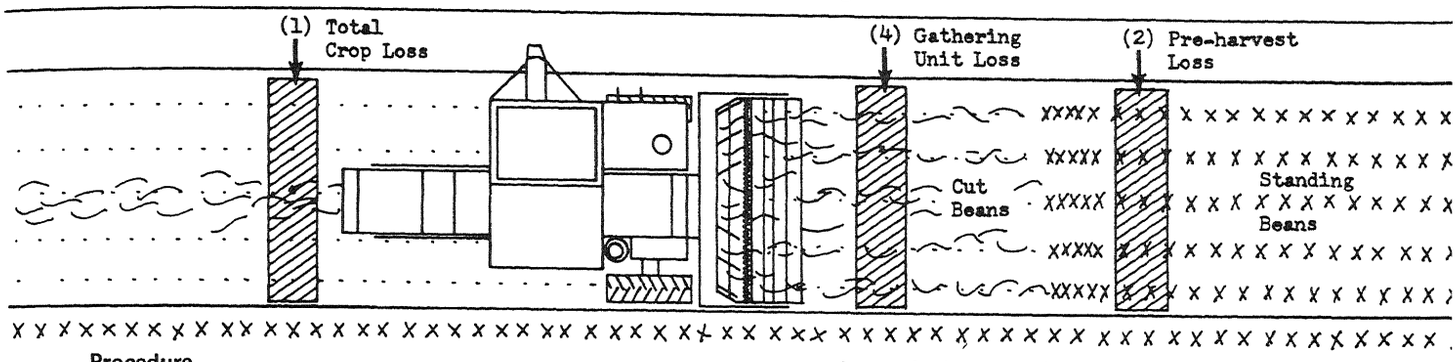


Figure 17. Harvest losses for the Beeson variety also increased drastically as the harvest date was delayed after the original dry-down phase. Lodging loss increased from 0.7 Bu./A to 3 Bu./A during this 20 day period.

Figure 18. Procedure for checking harvest losses



Procedure

1. Stop combine at least 300 feet in from ends of field and where crop is typical of entire field. Back up combine about 15 feet. Place rectangular frame across swath harvested at rear of combine. Count all beans in frame and enter this count in loss data table column 1-A. Divide this number by 40 and enter the loss in bushels per acre in column 1-B. If loss is near 3% of yield, keep right on harvesting. If loss is greater, then proceed to pinpoint the sources of loss.
2. Determine preharvest loss by placing rectangular frame in standing beans in front of combine. Count loose beans on ground and beans in pods laying loose on ground. Enter this number in column 2-A and then divide by 40 to get loss in bushels per acre. Enter this loss in column 2-B.
3. Machine loss is determined by subtracting the preharvest loss from the total crop loss. If machine loss is near 3% of yield or less, keep right on harvesting. If more, then proceed to check gathering unit losses.
4. Gathering unit losses are determined by placing the rectangular frame in the space between the parked combine and the standing beans. Then proceed to make bean counts as follows:
   a. Shatter loss—count all loose beans on ground and beans in loose pods on ground, subtract preharvest loss. Enter this number in column 4 a—A and enter bushels per acre loss in column 4 a—B.
   b. Loose stalk loss—count all beans in pods attached to soybean stalks that were cut but not gathered into machine. Enter this number in columnn 4 b—A and enter bushel per acre loss in column 4 b—B.
   c. Lodged stalk loss—count all beans in pods attached to soybean stalks that were lodged and are still attached to the ground. Enter this number in column 4 c—A and enter bushel per acre loss in column 4 c—B.
   d. Stubble loss—count all beans in pods still attached to stubble. Enter this number in column 4 d—A and enter bushel per acre loss in column 4 d—B.

   Total gathering unit loss is now obtained by adding the losses in column B for shatter, stubble, loose stalk, and lodged stalk losses. Enter this number in column 4-B.
5. Cylinder and separation loss is now determined by subtracting the gathering unit loss from the machine loss. Enter this difference in column 5-B.

Note: Now compare your harvest loss levels to those in column C. Then concentrate on machine adjustments and operating practices that will give the least total loss. Repeating these loss checks in different parts of the field will greatly increase their accuracy.

LOSS DATA TABLE

Source of Loss	**Column A** Beans Found in 10 Sq. Ft. Area	Number of Beans = To 1 Bu./Acre	**Column B** Your Bean Loss in Bu./Acre	**Column C** Desirable Loss Level in 40 Bu./Acre Yield
1. Total Crop Loss		40		**1.3**
2. Pre-Harvest Loss		40		**0.1**
3. Machine Loss		40		**1.2**
4. Gathering Unit Loss. Totals of:		40		**1.1**
a. Shatter		40		**0.4**
b. Loose Stalk		40		**0.2**
c. Lodged Stalk		40		**0.2**
d. Stubble		40		**0.3**
5. Cylinder and Separation Loss	////////////	////////////		**0.1**

bean loss is to make a rectangle with a piece of twine and four wire stakes or pins (these can be made from No. 9 wire). The rectangle should equal the machine swath and have a length that will enclose 10 square ft of area. (See table 2 for rectangular dimensions for various machine widths.) Then, make bean counts in this 10-square-foot area. Divide these counts by 40 and you have the loss in bu/acre.

The step-by-step procedure shown in figure 18 will make it easy to measure machine losses. Enter your loss counts in the loss data table and compare your loss levels to those of an expert operator (column C).

OPERATING PRACTICES

Operating practices that will help keep losses low include the following:

1. Have your machine in good state of repair. Sharp knife sections and ledger plates are essential. Make sure belts are tight and treated so they won't slip under load. Check combine for properly governed engine speed or PTO speed. This is basic.
2. Adjust reel speed to 25% faster than ground speed. For a 42-inch reel, this would be 11 rpm for each mile per hour ground speed. Increase reel speed where crop is lodged, but decrease reel speed back to normal when lodged area has been passed.
3. Position the reel so it enters the crop only *enough* to gain control. Hydraulic cylinders make it possible to change reel height while on the go. The reel axis should be 6 to 12 inches ahead of the knife.
4. Use "pick up guards" when the beans are lodged and tangled.
5. In short beans, 12 to 18 inches tall, the effectiveness of the reel can be increased by adding plywood strips to each reel bat, making the reel bat extra wide. Allow about 2 inches of the pick-up tines to protrude below the plywood bat.
6. Operate the cutterbar as close to the ground as possible. A floating cutterbar extension with an automatic header control is almost essential on self-propelled combines.
7. Forward speed should be right at 3 mph on most machines to prevent stripping of beans from stalk. Check stubble height. If it is uneven and jagged, forward speed should be reduced.
8. After beans have once dried to 13%, take advantage of damp pod conditions as influenced by light rain or dew. Shatter losses will be greatly reduced. Night harvesting should be considered. When pods are tough, use increased cylinder speed to thresh out beans, but watch for excessive cracking. Cylinder speed and clearance should be set according to the manual.
9. Measure your harvest losses at least once a day and for each different variety of beans harvested.
10. Keep a record of your harvest losses for different varieties, machine settings, and crop conditions.
11. Complete the harvest as quickly as possible after beans first reach 15% moisture.

I am sure you will agree that expert harvesting is not easy. It takes knowledge, skill, judgment, and dedication, as well as good equipment.

For those who have not seen new equipment operated in the field, I suggest you do as we have in Ohio. Arrange "soybean harvest clinics" with the assistance of your County Extension Agents and your farm machinery dealers. Demonstrate the different machines with various accessories and various adjustments. But, most important, is the measuring of the losses after each demonstration to note results. This is the real "proof of the pudding." In fact, if I were to list one priority item to get you on the road to "expert harvesting" it would be, "learn to quickly measure harvest losses." Once you have measured losses and actually see what you are losing, your commitment to expert harvesting will have been assured.

Table 2. Rectangular dimensions for 10-square-foot plot

Common machine swath	Distance to enclose 10 sq ft
8′	15″
10′	12″
12′	10″
13′	9.25″
14′	8.6″
15′	8.0″
16′	7.5″
18′	6.6″

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